Attorney Docket 82-2

APPLICATION OF Lewis PATENT

HEAT EXCHANGE SYSTEM

TECHNICAL FIELD

This invention pertains to the field of heat exchange and specifically to a more efficient design of heat exchangers.

BACKGROUND OF THE INVENTION

Plate fin and tube heat exchangers or externally finned tube exchangers have long been employed to recover process heat. These exchangers are most often employed to heat or cool a low density gas stream located on the finned side against a denser fluid with higher heat transfer coefficient within the tubes. The extended surface on the finned exterior pass allows greater heat transfer surface than a bare tube and provides greater heat transfer at a low-pressure drop.

The art has not heretofore recognized the unexpected advantage of using multiple process streams on the tube side of one or more heat exchangers and interlacing the heat transfer zones to allow more effective heat transfer was not recognized in the art. Kohlenberger U.S. Patents 5,790,972 and 5,444,971 disclose inlet cooling of a gas turbine using zones in series, but do not suggest the advantages of integrating the fluid circuits into one heat exchange zone.

SUMMARY OF THE INVENTION

The invention may be described in several ways as alternate embodiments of the same novel discovery.

A method for operating a heat exchanger of the plate fin and tube or finned tube type that can be used in heat transfer system that comprises:

a. providing a first working fluid on the finned exterior side of the heat transfer device,

b. providing two or more working fluids flowing in separate circuits within the tube circuits of the heat transfer device,

c. feeding the first working fluid to the exterior finned side of a heat transfer zone or zones to transfer heat to or from the first working fluid thereby heating or cooling the first working fluid to a higher or lower temperature,

d. feeding the second working fluid into a tube or group of tubes to be heated or cooled by the first working fluid,

e. feeding a third or more working fluid(s) into a tube or group of tubes to be heated or cooled by the first or second working fluid.

f. the multiple tube circuits being interwoven to more effectively approach the cooling curve of the finned external side fluid.

In a preferred embodiment the invention provides:

g. a heat exchange device having one or more finned exterior side working fluid streams against multiple tube side circuits,

h. the multiple tube circuits being interlaced to more effectively approach the cooling curve of the finned exterior side working fluid.

In a more preferred embodiment the invention further provides:

i. A method of circuitry of a plate fin and tube or finned tube exchanger that allows for more effective heat transfer by adjusting the cooling curve, by providing multiple working fluids in separate but integrated circulation paths.

j. A method of construction and design allowing complex circuitry of a plate finned and tube or finned tube exchanger utilizing multiple tube side circuits that are interlaced to accomplish more effective heat transfer than would be possible with multiple tube side fluid streams arranged in series without interlacing the circuitry.

The invention may be described as a method of recovering energy that comprises:

providing a multiple zone integrated plate fin and tube or finned tube exchanger that can be used in heat transfer system that comprises the steps of:

a. providing a first working fluid circulation path on a finned exterior side of a heat transfer device,

b. feeding the first working fluid to the circulation path on the exterior finned side of a heat transfer zone to transfer heat to or from the first working fluid thereby heating or cooling the first working fluid to a higher or lower temperature,

c. feeding a second working fluid into a second circulation path within the heat exchanger to be heated or cooled by the first working fluid.

d. And feeding a third fluid into a circulation path to be heated or cooled by the first working fluid or the second working fluid.

Fluids of the same or different composition may be used.

An alternative embodiment is a method of construction of a heat exchanger that comprises providing a plurality of circulation paths in a plate fin and tube or finned tube exchanger utilizing a plurality of tube side circuits that are interlaced to accomplish more effective heat transfer than would be possible with a plurality of tube side fluid streams arranged in series without interlacing the circuitry.

As noted above first working fluid and the second working fluid have the same composition or the working fluids may be of different composition.

The invention may also be described as an energy recovery apparatus specially designed to practice the methods described above that comprises:

a. A finned surface heat exchanger comprising a plurality of circulation pathways for a plurality of working fluids, and

b. circulation means to pass a plurality of working fluids into at least one heat exchange zone. For example the apparatus may comprise a plurality of working fluid streams on the tubing interior side of a plate fin and tube or finned tube exchanger. In a preferred embodiment the apparatus further comprises multiple heat recovery stages to provide additional heat recovery.

The inventive concept may also be embodied as a method for an energy recovery system for increasing the efficiency of a gas turbine exhaust heat recovery by providing an integrated tube side heating circuitry to heat a plurality of working fluid circuits while cooling the exhaust stream of the gas turbine.

In summary, the invention provides a system for more efficient heat transfer in a plate fin and tube or finned tube exchanger by providing a plurality of separate working fluids in a plurality of working fluid circulation paths.

The invention is illustrated by the specific example set out below.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a sketch of a typical integrated coil having two working fluids in separate circuits.

Figure 2 is a sketch of an integrated coil having 4 working fluids with interwoven circuitry.

DETAILED DESCRIPTION OF THE INVENTION

The invention provides a method of interweaving streams with various working fluids in a common plate fin and tube or finned tube exchanger to accomplish more efficient heat transfer.

The invention may be employed to increase the hear recovery efficiency of any gas turbine or other device that produces a waste heat exhaust or is a source of process heat. Alternatively the arrangement may produce more efficient refrigeration at locations requiring refrigeration or cooling.

These examples are provided to illustrate the invention and not to limit the concepts embodied therein. The invention is defined and limited by the claims set out below. The examples below were modeled using a commercial process simulator.

Example 1

In Figure 1 a simple two fluid system is shown. The principals illustrated in the more complex system also apply to the two fluid system of figure 1. Turning to Fig. 2, a first working fluid consisting of 88.67mol % N2 and 11.32 mol % H2O enters the heat exchanger at 263.2F, 366.5 psia, 18,946 moles/hr and leaves the exchanger at 101.9 F, 363.3 psia. It exchanges heat with a 2nd working fluid , natural gas in this illustration, entering at 45.6 F, 512 psia, 4460 moles/hr and leaving at 241.5 F, 501 psia. The first working fluid also exchanges heat with a 3rd working fluid, water, entering at 74.4 F, 61 psia, 17660 moles/hr and leaving at 209.5 F, 42.8 psia. The first working fluid also exchanges heat with a 4th working fluid, water, entering at 92 F, 54.7 psia, 20,900 moles/hr and leaving at 107 F, 44.7 psia. The exchanger is modeled with fluid separation and removal after each heat exchange zone as can be accomplished with the invention device. Under the invention integrated heat exchange design, the total UA required is 934,180 BTU/F-hr. If working fluid streams 2, 3 and 4 are arranged in series without integrated heat exchange and with fluid separation and removal after each heat exchange zone, the total UA required to accomplish the same leaving working fluid 1 temperature is 1,127900 BTU/F-hr. In this example the flow-rate of the 4th working fluid is increased from 20,900 moles/hr to 25,760 moles/hr. Since UA is the heat transfer coefficient times the required heat transfer area, one can assume the heat transfer coefficient is essentially the same. Therefore the invention integrated heat exchanger design using the interwoven heat transfer zones can achieve the same desired working fluid 1 exit temperature with 20.7% less heat transfer area.

The working fluids may be any available fluid that can be circulated at pressures within the design limits of the selected exchanger and will be selected depending on available fluids at the site. They may include multiple streams of the same fluid at different temperatures and pressures (such as water in example 1) or the fluids may be different (such as natural gas, working fluid 2 in the example).